Supply-side Determinants and Potential Magnitude of Economy-wide Rebound Effects: Overview of Key Findings from a Research Project Funded by the UK Economic and Social Research Council

Paper linked to presentation 'Sector Analysis/Empirical Evidence: Industrial Sector'

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Distinction between energy efficiency improvements in production (industrial) and consumption (household) behaviour
Most of the work in our project has focused on the impacts of increased efficiency in the use of energy in production, though more recently we have begun to look at energy efficiency improvements in household (final) consumption activity (see Lecca et al, 2011a). Note that it is important to note that by energy efficiency improvements we are referring to technological progress (i.e. a change in technology that permits more output to be gained for a given physical input of energy – not behavioural or price induced changes that cause us to use less energy without changing the output that is gained from physical input).

We have found that there is a key distinction in how increased energy efficiency transmits to the wider economy (i.e. determination of the economy-wide rebound effect) depending on whether it takes place in production or consumption activities:

- An energy efficiency improvement in production equates to a productivity change in the economy. The source of economy-wide rebound is also a source of economic growth - i.e. increased competitiveness
- Energy efficiency improvement in final consumption, on the other hand, transmits to supply-side of economy in two ways:
    1. Through a shift in demand. If rebound is less than 100%, there will be a reduction in demand for energy and increase in demand for other goods and services
        - Note that such a domestic demand stimulus may actually reduce competitiveness throughout the target economy. That is, there may be GDP growth, but with a crowding out of export demand. Thus, this is quite different to an improvement in productivity on supply side when energy efficiency improvements take place on production/industry side of economy. However, if the change in real income (and purchasing power) triggered by an energy efficiency improvement leads to reduced real wage demands, this may become more similar to a productivity improvement (reducing the cost of labour supplied by households to the production side of the economy).
    2. If the demand for energy is reduced, this means falling demand for energy supply outputs. This may trigger two type of effect, *which also occur when efficiency increases in use of energy on the production side of the economy*. These are (a) negative multiplier effects throughout the economy, particularly impacting energy supply itself given what is generally relatively high energy intensity of energy production, and (b) downward pressure on price of output in energy production. In the case of (b), if revenues and profitability fall as well, this will affect the return on

capital and decisions regarding the replacement of worn out capital and installation of new capital. That is, it may trigger 'disinvestment' rather than investment in energy supply. Note that (a) may be considered in an input-output framework but (b) requires a CGE modelling framework where both changing prices and quantities may be considered.

Use of CGE models in this project

This project set out to estimate the magnitude of rebound in the UK through empirical CGE modelling studies for Scotland and UK. The motivation for using CGE methods is their ability to capture complex inter-sectoral and inter-market relationships in an economy-wide context. However, in the progress of the research it became clear that the theory in terms of determinants of economy-wide rebound required further development and most of the work has involved using the empirical CGE models for more analytical work. That is, using sensitivity analysis, running simulations under different assumptions in order to identify and consider the relative importance of different key determinants of and constraints on economy-wide rebound. We have found that key parameters are export demand elasticities and elasticities of substitution in production. In the case of the latter we have also investigated the importance of the structure of production functions, with particular attention to how energy enters (see Lecca et al, 2011b).

It is worth noting, that in the empirical analyses, we found it quite difficult to get an outcome of backfire (R>100%) so generally thinking about some energy saving, but just not as much as may have anticipated from the initial efficiency improvement. Where we did find backfire, unless we assumed key elasticities of substitution to be greater than one, these were driven by competitiveness effects resulting from productivity improvements. Our main backfire finds were found where energy efficiency improvements take place in the heavily traded and energy intensive energy supply sectors in Scotland. However, before asserting that this is a likely outcome, we need to consider how to model energy supply sectors and pricing.

Again, the focus of this project became less to determine the likely magnitude of rebound in the UK national and regional economies than to first identify and understand the key determinants of economy-wide rebound.

Project focus on supply-side determinants of economy-wide rebound

Rebound is triggered by a demand response to the change in the implicit price of energy when efficiency in its use increased. The direct and derived demand for energy has been focus of much of the existing rebound research in the literature. However, in considering both indirect and economy-wide rebound, the supply response to changing demand, prices and incomes is crucial, particularly in energy supply. We have found that two broad types of supply responses are important.

First, our research shows that the negative multiplier and disinvestment effects in energy supply discussed above) will constrain the size of indirect and economy-wide rebound effects (possibly even causing them to be negative). In the case of disinvestment, this may lead to long-run rebound being larger in short run than in long-run. See Turner (2009) and Anson and Turner (2009). As noted above, we have found these supply-side effects to be important whether energy efficiency improvements take place in production or consumption. However, there presence and importance depends on the nature of energy supply.

One issue is that it is important to be clear on what we mean by energy supply and use. For example, the price of oil is a world price. However, we don't consume crude oil. We consume refined/produced energy – e.g. petrol sold at pumps, electricity generated from renewable or non-renewable sources. The price of such *produced* energy (rather than energy as a primary input) is set in local markets.

This is what gives us the disinvestment process. When we have a reduction in demand for energy from an efficiency improvement (the initial efficiency effect), this pushes down price faced by energy suppliers. Now this may mean further impetus for economy-wide rebound. However, if demand is not sufficiently responsive (i.e. quantity demanded rises proportionately less than price falls), revenues will fall in energy supply sectors. If revenues fall, there is a decrease in the return on factors of production, particularly capital in what tend to be capital intensive activities. So the question is, how do energy suppliers and their investors respond?

In our research to date, we have focussed on domestic energy supply sectors (in same economy as where efficiency improvement takes place). However, where we import energy services, there may be be important interregional/spillover effects. This will be considered in future research.

The second area of supply-side effects that we have found to be important (whether energy efficiency improvements are introduced on the consumption or production side of the economy) relate to how factor markets adjust. That is, general capital market and investment responses (not just in energy supply sectors) and labour market responses, in terms of wage setting and migration behaviour. In considering these, it is particularly important to model dynamic adjustment processes in a CGE context. See Hanley et al (2009) and Turner and Hanley (2011).

Note on nature of energy efficiency improvements considered to date

To date, we have generally made the simplifying assumption that energy efficiency improvements are exogenous and costless in order to focus on response to change in implicit/effective price of energy (rebound trigger). This tends to be true across most CGE analyses of economy-wide rebound to date. However, we have done some work looking at potential costs (and use of revenues – see Allan et al, 2007, reference below). The key thing is that any cost of introducing imposed on energy user will reduce the effective price change that is the rebound trigger.

Intended future research

In the next stage of our research we will focus on relaxing the assumption that energy efficiency improvements are exogenous and costless (with particular focus on efficiency improvements in energy supply itself – this will involve input from electrical engineering colleagues) and further exploring the supply-side determinants of economy-wide rebound. We also aim to extend our empirical focus to other EU member states, both in terms of considering key relationships (such as production and migration functions) and carrying out analysis of economy-wide rebound effects using CGE techniques. We are in the process of making an application to this end to the European Research Council.

Outputs cited above:

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